Mansoura University	Faculty of Engineering	Electronics and Comm. Dept.	4th Year, Optical Communication Systems	9/11/2015	Sheet #3

Q_1. Estimate the following relations for bulk semiconductor materials using Boltzmann's approximation

a) Number of free electrons in C.B

b) Number of holes in V.B

c) Intrinsic carrier concentration

d) Fermi level energy for intrinsic materials

e) Fermi level energy for N-doped materials

f) Fermi level energy for P-doped materials

g) The conductivity

Q_2. Draw the energy band diagrams and indicate approximate positions for Fermi levels for

a) Intrinsic semiconductor materials.

b) N-doped semiconductor materials.

c) P-doped semiconductor materials.

d) PN-junction at thermal equilibrium.

e) PN-junction at Forward Bias.

f) PN-junction at Reverse Bias.

Q_3. Complete with suitable words

1. GaAs is classified as…..semiconductor,

2. Si is classified as..... semiconductor.

3. The material $Al_x Ga_{1-x}$ As is grown over.....substrate

4. $In_{1-x} Ga_x AS_y P_{1-y}$ is grown over ..... substrate.

5. For $Al_x Ga_{1-x} As$, at x ..... 0.45 , the material is considered as direct band gap.

6. The cut off wavelength of Si material is..... .

7. Si can be used as ..... while GaAs can be used as..... .

8. As the band gap energy ..... the intrinsic carrier concentration increases.

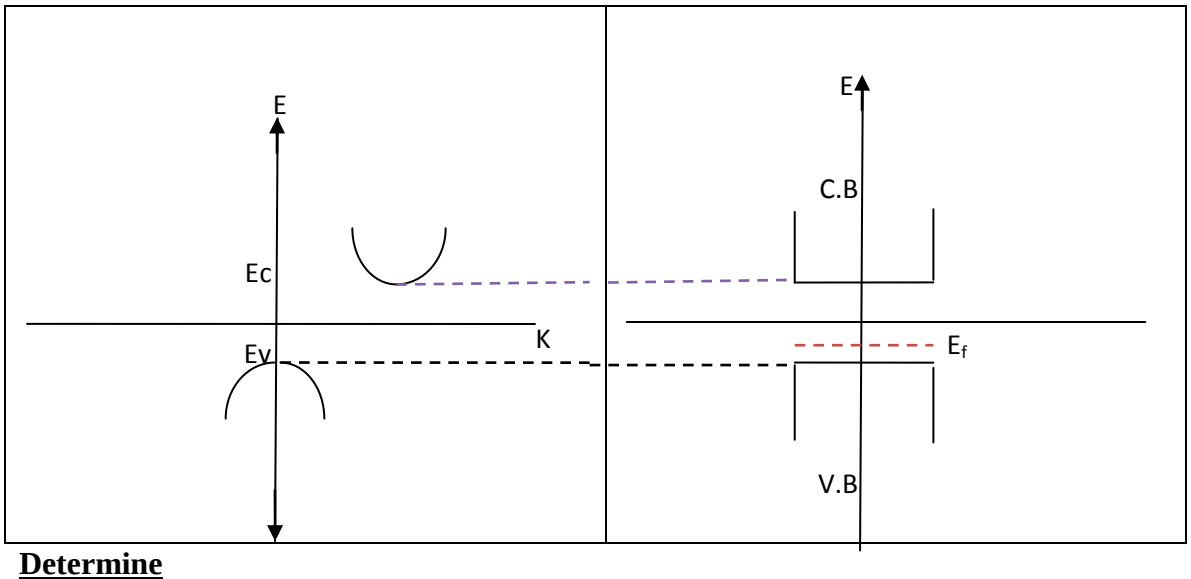
9. As the effective mass increases the intrinsic carrier concentration for bulk material…...

10. The direct band gap energy of $Al_{0.2}Ga_{0.8}As$ is equal to .....

11. The indirect band gap energy of $Al_{0.6}Ga_{0.4}As$ is equal to .....

12. The term PIC stands for…... and the fabrication of the PICs depends on ……process

Q_4. Given the following schematics diagrams for a semiconductor material where at room temperature, E_c= -56 eV, E_v= -60 eV and E_f= -59 eV



Determine

a) The type of material (either direct or indirect) and determine its appropriate application
b) Is the material intrinsic or extrinsic? if it is extrinsic, determine if its N-type or P-type, Give reason for your choice?

c) Calculate the probabilities of finding electrons at E=-55 eV, E=-62 eV.

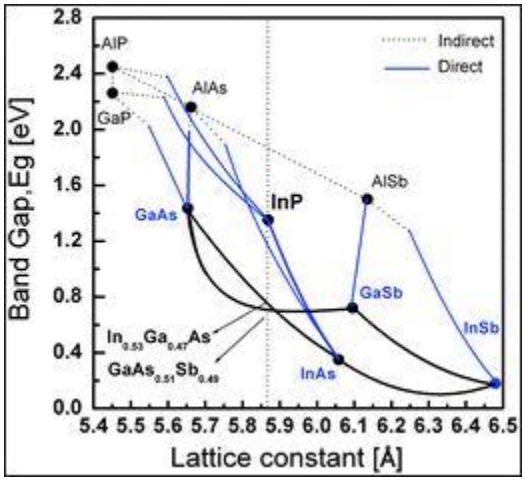
d) Calculate the probabilities of finding holes at E=-62 eV E=-63 eV

Q_5. Make a comparison between

a) Alloying and Doping
b) Homojunctions and Heterojunctions
c) Anisotypre heterojunction and Isotype heterojunction (compare & give examples)
d) Straddling, Staggered and Broken-gap heterojunctions (use schematics diagrams)
e) Radiative transition and Non radiative transition
f) Materials: $Al_{0.2}Ga_{0.8}As$ and $Al_{0.6}Ga_{0.4}As$ (bandgap- type- application)

g) Structures: N-GaAs/ N-$Al_{0.2}Ga_{0.8}As$, N-Si/ P-Si, N-GaAs/ P-$Al_{0.6}Ga_{0.4}As$ and P-GaAs/ N-$Al_{0.6}Ga_{0.4}As$
h) Heterojunction lables nN, Pp, Np and Pn

Q7. Give reason for

a) Un Matched heterojunctions are not preferred for obtaining optoelectronic devices
b) $Al_{0.6}Ga_{0.4}As$ is not preferred for designing optical sources
c) Alloying
d) Doping
e) Fermi level in the intrinsic semiconductor is approximately midway between the minimum edge of the conduction band and the maximum edge of the valence band
f) Fermi level in the N-type semiconductor is approximately near the minimum edge of the conduction band
g) Forward biased P-GaAs/ N-GaAs junction can be used as optical source
h) Reverse biased P-Si/ N-Si junction can be used as absorber for wave (λ =500 nm)

Q_8. The following diagram shows the relation between the energy bandgap and lattice spacing for different semiconductor materials; based on the given diagram suggest alloys for designing optical sources and optical detectors. Give reasons for your suggestions.